IES Newsletter

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Editor's Note

During the colder months of the year, the Institute's greenhouse is considered by many of our visitors to be a tropical getaway ... an island of flowers, greenery and warmth in a cold sea of snow and ice.

In addition to cycads—the 'living fossils' introduced on page 3—plant enthusiasts encounter scented geraniums (rub the leaves to learn how they got their name), a herb collection complete with herbal fact and folklore, and carnivorous plants. (Do you know why they trap insects? Signs in the greenhouse explain.) January and February bring out the best in the begonia collection, and some of the orchids are blooming. Ponderosa lemon trees are laden with grapefruit-sized fruit, and other citrus trees are doing their best to compete.

Beneficial insects and their relatives help contribute to the health and well-being of the greenhouse ecosystem ... there has not been a general pesticide spraying in the facility for four years. During your visit, keep an eye out for the green lacewing, whose larvae eat aphids, white flies and mealybugs.

The IES Newsletter is published by the Institute of Ecosystem Studies, located at the Mary Flagler Cary Arboretum in Millbrook, New York. All newsletter correspondence should be addressed to the editor.

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Small Creatures Make Big Impact on Soil

IES postdoctoral associate Dr. Patrick Bohlen is intrigued by a worm-filled soil patch. "Wormy soil is like a plow layer," he says, "with mineral soil completely mixed with the organic matter." Among his reasons for valuing these living earth mixers are that they are a key food source for larger animals and can be biological indicators of pollution.

Dr. Bohlen has yet another reason for holding earthworms in high regard: their important influence on retention or loss of nutrients in the soil system. Indeed, his years of experience observing worm-filled soil stem from his dissertation work on this topic, completed at Ohio State University.

Dr. Bohlen, who is coauthor of the third edition of the book *Earthworm Biology and Ecology* (now in press), says the explosion of interest in earthworms over the past decade is testimony to their importance. Still, much remains to be discovered about the factors that influence earthworm abundance and diversity in agricultural soils. Also largely unknown are the ways in which earthworms, in their complex communities, affect soil processes, and the ways they will be affected by new agricultural practices such as no-till agriculture. "Soil is a three-dimensional living system; a lot is going on," Dr. Bohlen says. Experimental evidence suggests that earthworms and microbes are synergistic — there are even microbes in the earthworm gut that provide nutrition.

One of Dr. Bohlen's pursuits at IES is a study of denitrification as it relates to earthworm activity. Denitrification is the process by which nitrate is converted to other nitrogen forms, such as the gases nitrous oxide — a greenhouse gas that contributes to global warming — and elemental nitrogen (nitrogen gas). Denitrification is important because it is one of the pathways by which nitrogen moves out of terrestrial ecosystems into the atmosphere, and there is evidence that earthworms are influential in increasing this process.

Dr. Bohlen, with the collaboration of his supervisor, microbial ecologist Dr. Peter Groffman, is taking advantage of the fact that nightcrawler worms dig fairly permanent vertical burrows, about 10 millimeters (0.4 inches) in diameter and one to two meters (3 to 6 feet) deep. The scientists are taking samples of soil from the burrows of nightcrawlers to provide insight into whether the burrows are local 'hot spots' of denitrification. Since there are 80 to 90 nightcrawlers in a square meter of soil, these hot spots could add up to a lot of denitrification.

Another thrust of the nitrogen work is to see whether the amount of free inorganic nitrogen in the soil depends on the numbers of earthworms. To determine that, Dr. Bohlen is measuring the nitrogen in test plots whose earthworm populations have been experimentally increased or decreased.

Exotic Asian Earthworms in Forest Soils

Dr. Bohlen is supervising another earthworm-related study being done by a Rutgers University student, Amy Burtelow, who participated in the 1995 Research Experiences for Undergraduates Program at IES (see IES Newsletter 12:4). The point of departure for her research was the recent observation that exotic (that is, non-native) earthworm species are colonizing previously worm-free forest soils, and in particular, glaciated soils.

In many soils in the northeastern U.S. once covered by glaciers, there were no earthworms before Europeans arrived, and these soils still are not likely to have native worms. What are often found are 'peregrine' species, which are worms with fairly wide distributions, not native to the Northeast. Working at IES, Ms. Burtelow searched along stream corridors and near wetlands for an Asian worm that, preferring wet soils, is expanding its range. She is looking at the earthworm's influence on denitrification and the cycling of nutrients using techniques similar to those used by Dr. Bohlen.

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MOLLY AHEARN

In an IES laboratory, Dr. Bohlen uses a gas chromatograph with autosampler to determine nitrous oxide concentrations in gas samples from soil incubations.

Nitrate: A Hidden Cost of Increased Farm Yields

In our industrialized world, with its high chemical-input agriculture, farmers apply a great deal of nitrogen-containing fertilizer, a practice that has increased crop yields but also has elevated the levels of nitrate in soil and groundwater. Unfortunately, high nitrate levels are toxic to humans — prolonged drinking of water with high nitrate concentrations can lead to methemoglobinemia (oxygen deficit in the blood), especially in infants. This is where Dr. Pierre-André Jacinthe, a new IES post-doctoral associate working with Dr. Peter Groffman, comes in. His work — using microbes to convert nitrate to other substances — could give a boost to the critical effort to find a way to limit nitrate in groundwater.

In his doctoral research at Ohio State University, Dr. Jacinthe had studied ways to manipulate natural systems to encourage them to remove nitrate from the soil by converting it to nitrous oxide and elemental nitrogen (nitrogen gas). Dr. Jacinthe says, "At the end of the growing season much of the nitrogen is left in the soil and remains in the frozen soil through the winter. As the soil warms up in the spring, soil microbes become active, producing more nitrate. In some years the soil nitrate level in March is two to five times what it was in November. With abundant precipitation in the spring, the nitrate percolates down into the groundwater. The result is a spring pulse of nitrate in groundwater."

MOLLY AHEARN

Dr. Jacinthe uses a dissolved oxygen meter to measure oxygen levels in streamwater samples.

Dr. Jacinthe knew that microbes (mainly denitrifying bacteria) in waterlogged, oxygen-poor soil would efficiently convert nitrate to other (gaseous) forms. Because many Ohio fields have drainage systems in place, the researcher's idea was to close the drains in spring in order to bring the water table up and get more microbial conversion of nitrate to the other forms.

To test this idea, Dr. Jacinthe did a simulation using big soil columns, 90 centimeters (3 feet) long and 30 centimeters (1 foot) in diameter. In the laboratory he devised an apparatus that would bring water up from the bottom of the column to a desired distance from the top surface of the column. This simulates the water table in the agricultural fields. Dr. Jacinthe explains, "Since the soil bacteria are in the top 5-15 centimeters (2-6 inches) of the soil, if the water table does not reach that zone, there will be no significant effect. Bringing the water to that height, I was able to remove 40 percent of the nitrate over 130 days. I also found that the longer the water table remains near the surface (hence the longer the soil is oxygen-deprived) the more nitrogen ends up in the elemental form." Dr. Jacinthe's solution was not perfect: nitrous oxide, one of the products of nitrate conversion, is an ozone-depleting and greenhouse gas. "Much less nitrous oxide would be produced if we could keep the water table high for long periods, in order to encourage formation of elemental nitrogen. But the limitation is time: farmers need to use their fields! Usually the spring thaw is in March and plowing begins in late April. So there is a 30- to 45-day window to use this technique," says Dr. Jacinthe.

At the Institute Dr. Jacinthe is continuing nitrate conversion studies, but in a riparian wetland. These wetlands are the transition zone between uplands and surface water; they are dry but have a high water table. Dr. Jacinthe's work addresses an earlier observation by Dr. Groffman, that nitrate added to the shallow groundwater of riparian wetlands disappears at rates much higher than one would predict from laboratory experiments.

Field research also reveals that a disproportionate amount of the nitrate disappears in March. Clearly, higher plants are not responsible since they are not active in March, which suggests that microbes are primarily responsible for the nitrate disappearance. Dr. Jacinthe is testing the idea that patches of organic material below the soil surface, rather than the soil at large, may harbor high concentrations of denitrifying microbes. He is looking for such patches by digging pits to take soil-core samples below the mean elevation of the water table. He will pump nitrate through the cores to see how much nitrogen is removed and how much nitrous oxide and nitrogen gas are produced. And he will also measure the overall metabolic activity of the core samples by measuring oxygen consumption. In other core samples he will add both nitrate and organic carbon (prepared by extracting soluble organic material from forest-floor litter) to see if the addition of carbon affects the denitrification process.

Dr. Jacinthe thinks his biggest headache will be making sure his experimental systems remain at specific oxygen levels. "The key to this," he says, "is to be patient at the beginning to make sure it is all working right."

The nitrate problems that plague the industrialized world are generally absent from traditional agricultural societies. "At home in Haiti and in many other underdeveloped countries," says Dr. Jacinthe, "inorganic nitrogen fertilizers are too expensive and not widely used." 'Home' for Dr. Jacinthe is Arcahaie, about 50 kilometers north of Port-au-Prince. In Haiti, commercial fertilizer is used mostly with rice and with specialty crops. "In Arcahaie we grow plantains, which we plant in May or June. For nitrogen we intercrop a variety of black-eyed peas (a legume and nitrogen fixer) in summer, leave the pea plants standing after pea harvest, and in December plant a bean (another legume). The plantains are finished in two to three years, and we plant sugar cane to break the cycle." Nitrate in groundwater, then, is one of the many hidden costs of chemical fertilizer use.

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Dr. Pierre-André Jacinthe, who says he has known since his second year in college that he was going to be a soil scientist, received an undergraduate degree in agronomy from the Faculté d'Agronomie et de Médecine Vétérinaire, in Port-au-Prince, Haiti. He received a masters degree from Ball State University in Muncie, Indiana, and this past June a doctorate from Ohio State University. Dr. Jacinthe arrived at IES in August. His work at the Institute is being funded through a National Research Initiative grant of the U.S. Department of Agriculture Water Resources Assessment and Protection Program.

"Living Fossils" Nurtured in Greenhouse

Sidle past the luscious citrus and the imposing staghorn ferns. Across the aisle from the succulents, cheek-by-jowl with the bird of paradise plant, are the greenhouse's very own cycads, 'living fossils' that more than manage to hold their own against the other spectacular denizens of the Institute's greenhouse.

Mr. David Bulkeley, IES greenhouse manager, has become an enthusiast of these handsome dark green plants and the greenhouse displays several different cycads. One, *Cycas taiwaniana*, native to an area reaching from Madagascar to Japan, was raised from seed brought from Hawaii some 19 years ago. So successful was the germination that Mr. Bulkeley was able to donate some of the plants to the U.S. Botanical Garden in Washington and to The New York Botanical Garden in the Bronx.

A second species, *Cycas revoluta*, came in a small pot from the Franklin D. Roosevelt Home in nearby Hyde Park, ("that makes it historically as well as botanically interesting," Mr. Bulkeley says). Another gift was *Cycas circinalis*, native to an area extending from India to New Guinea. Both of these cycads are grown extensively as ornamentals, reaching nearly tree size outdoors in the tropics. *C. revoluta* is also widely used for bonsai in Japan.

Looking much like palms, cycads are entirely unrelated to them and in fact are an ancient and primitive group of plants. Their requirement for warm climates and the fact that they are gymnosperms (from the Greek *gymnos*, naked, and *sperma*, seed, with the unprotected seed lying on the scales of the female cone), testify to their origin in the Mesozoic era, some 100-200 million years ago. They were witness to giant reptiles roaming a warm Earth and a landscape dominated by spore-bearing ferns. For tens of millions of years the cycads ranged widely over the Earth, and with their dying they made an important contribution to the formation of coal.

Over time, changes in the Earth's weather and increasing competition from flowering plants gradually reduced cycad habitat; today, some 168 species of cycads — 10 genera in three families — survive. All tropical and subtropical, cycads differ from such familiar gymnosperms as pines and spruces in the internal structure of the stems and roots and details of the reproductive structures. Cycad plants are either entirely male or entirely female, so seed production is only possible when plants of both sexes grow together and mature at the same time; in cultivation, artificial pollination is necessary. Months after pollination, the female cone matures — a single, large, fuzzy structure growing from the center of the plant— and, as it disintegrates, ripe seeds are released. (Unfertilized cones develop in a similar way and regularly appear on the IES greenhouse cycads, but their seeds are not viable.)

Of these tenacious survivors of an earlier time, a number of species are teetering on the brink of extinction and the group as a whole is probably the most endangered group of plants in the world. A few are imperiled due to destruction of their special habitats — as, for example, in Florida and South Africa, where land is being cleared for development or agriculture. Probably the main cause of their decline, however, is overcollection for the horticultural trade. These graceful plants had been traded for more than two centuries with little impact, but since the 1970s, when they began to be regarded as collector's items and traders began to command steep prices for certain rare species, the number of cycads in illegal trade has climbed sharply. They are protected by the U.S. Endangered Species Act and the international treaty on endangered species, but smuggling schemes abound — for example, some are deliberately mislabeled as palms or ferns, in order to slip them past inspectors at the Mexican-U.S. border.

Fortunately, as Mr. Bulkeley points out, a considerable number of cycad species are being commercially propagated to meet the horticultural demand and thwart the collectors of wild-grown stock. Home-greenhouse enthusiasts interested in growing cycads of their own should make sure their supplier is offering only nursery-grown stock.

But cycads are slow-growing, and private growers will have to wait years before their specimens look showy. Fortunately, here at the IES greenhouse, the cycad specimens are all thriving, and visitors are welcome to stop by and make their acquaintance.

MOLLY AHEARN

Here, Mr. Bulkeley has selected one of the six cycad plants in the IES greenhouse to point out a seed in a well-developed cone.

Small Creatures, *from page 1*

Studying Forest-Floor Microbial Processes

Though a big part of Dr. Bohlen's work, earthworms are just one facet of his overriding interest in soil ecology, the relations and interactions among invertebrates, microbes and nutrient cycling. At the Hubbard Brook Experimental Forest in New Hampshire (see IES Newsletter 12:4), Dr. Bohlen is studying the factors controlling the microbial processes of the forest floor. "Some (but not all) carbon and nitrogen 'pools' of the forest floor are taken up, metabolized, and turned over very rapidly," he explains. "These pools provide information on what resources the microbial populations have to work with. We'd like to trace the movement of nutrients through these pools: from the leaf, through the leaf litter on the forest floor, to the soil. And in particular, we'd like to relate that movement to litter fall, litter type, and the flow of nutrients."

In one experimental approach Dr. Bohlen fed a solution containing a naturally-occurring nitrogen isotope into a tree by puncturing the bark and attaching a solution-filled collar that directed the fluid into the transpiration flow of the tree. In this way, he created beech and maple leaf litters that are 'labeled' with the nitrogen isotope, enabling him to track the nitrogen flow. He hopes to relate the information he obtains about leaf litter to information on what nutrients are going into the soil.

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Dr. Bohlen received his undergraduate degree from the University of Michigan. Before obtaining a masters degree from Miami University in Ohio and a doctorate from Ohio State, he spent a year at Wes Jackson's Land Institute, the well-known 'alternative' agricultural research center in Salina, Kansas. He arrived at IES in May 1994.

Calendar

CONTINUING EDUCATION

Winter/Spring semester catalogues are available at the Gifford House or by calling the Continuing Education Program office number below. Following are just some of the upcoming classes, workshops and excursions:

Landscape Design

Feb. 8: **Marketing and Estimating Landscape and Gardening Services**
Feb. 24: **Residential Design Sketch Exercises**

Gardening

Feb. 3: **Hows of Houseplants**
Feb. 3: **Developing Ecologically-Sound Nursery and Landscape Practices**
Feb. 5 (6 sessions): **Fundamentals of Gardening**
Feb. 10: **Gardens for Dry Sites and Dry Years**
Feb. 24: **Topiaries, Standards and Beyond**

Workshops

Feb. 4: **The Landscape with Perennials in the Mixed Border**
Mar. 3: **Wildflower Celebration**

Other Courses

Feb. 24 & Mar. 2: **Introduction to Flower Arranging**

Excursions and Tours

Feb. 26: **Philadelphia Flower Show**

Call the Continuing Education Program office at 914/677-9643 for information.

SUNDAY ECOLOGY PROGRAMS

Free public programs are held on the first and third Sunday of the month, except over holiday weekends. Last-minute changes are sometimes unavoidable, so call 914/677-5359 to confirm the day's topic. In case of poor weather, call 677-5358 after 1 p.m. to learn the status of the day's program. The following programs begin at 2 p.m. at the Gifford House, except as otherwise noted*:

Feb. 4: **Echoes of the Ancient Skies**, a program for children and their families (* to be held at the IES auditorium)

Sunday Ecology Programs, continued

Feb. 18: Holiday weekend (no program)
Mar. 3: **Human Accelerated Environmental Change**, a slide presentation by Dr. Gene E. Likens (* to be held at the IES Auditorium)
Mar. 17: **A Catskill Conundrum**, a slide presentation by Dr. Kathleen Weathers

IES SEMINARS

The Institute's program of free **scientific seminars** features presentations by visiting scientists each Friday at 3:30 p.m. at the IES Auditorium:

Jan. 19: **Indeterminacy (?) of ecological reactions in an oldfield food web as revealed by perturbation experiments**. Speaker: Dr. Oswald Schmitz, School of Forestry and Environmental Studies, Yale Univ.
Jan. 26: **Adaptive sampling strategies**. Speaker: Dr. Steven K. Thompson, Penn State Univ.
Feb. 2: **Experimental studies of avian frugivory**. Speaker: Dr. Kathy Winnet-Murray, Hope College
Feb. 9: **Community-level consequences of competition**. Speaker: Dr. Deborah Goldberg, Univ. of Michigan

VOLUNTEER OPPORTUNITIES

The IES Volunteer Program is looking for enthusiastic women and men interested in working with Institute staff for a few hours (or more) each week at the Gifford House Visitor and Education Center. For information on responsibilities and benefits, call Su Marcy, IES volunteer coordinator, at 914/677-5359.

GREENHOUSE

The IES greenhouse, a year-round tropical plant paradise and a site for controlled environmental research, is open until 4:00 p.m. daily except public holidays. Admission is by free permit (see "Hours").

IES HOME PAGE

The Institute is on the World Wide Web. Visit the IES home page at: **http://www.marist.edu/~ies/**

HOURS

Winter hours: October 1 - April 30
Closed on public holidays.
Roadways are closed when snow-covered.

Public attractions are open Mon. - Sat., 9 a.m. - 4 p.m. & Sun. 1 - 4 p.m., with a free permit.
The **IES Gift and Plant Shop** is open Mon.- Sat., 11 a.m. - 4 p.m. & Sun. 1 -4 p.m. (The shop is closed weekdays from 1 - 1:30 p.m.)

• *All visitors must pick up a **free permit** at the Gifford House Visitor and Education Center on Route 44A for access to IES public attractions. Permits are available until 4 p.m. daily.*

IES GIFT AND PLANT SHOP

January Sale: Discounts all month!!
New in the Shop ... bluebird, chickadee and wren birdhouse kits ... bat house kits ... bird feeders ... brass bookmarks ... **and in the Plant Shop** ... scented geraniums ... staghorn ferns ... FELCO pruners and sheaths ... gardener's soap
Senior Citizens Days: 10% off on Wednesdays

MEMBERSHIP

Become a member of the Institute of Ecosystem Studies. Benefits include a member's rate for IES courses and excursions, a 10% discount on Gift Shop purchases, a free subscription to the IES Newsletter and participation in a reciprocal admissions program, with benefits at over 100 nature centers, forest preserves, gardens and conservatories in the U.S. and Canada. Individual membership is $30; family membership is $40. For information, call Ms. Janice Claiborne at 914/677-5343.
The Institute's Aldo Leopold Society: In addition to receiving the benefits listed above, members of The Aldo Leopold Society are invited guests at spring and fall IES science updates. Call Ms. Jan Mittan at 914/677-5343 for information.

For general information, call the IES Education Program Office at the Gifford House Visitor and Education Center: 914/677-5359 weekdays from 8:30 a.m. - 4:30 p.m.

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